ROLLER BEARING

This invention relates to a roller bearing and in particular, though not exclusively, to a roller bearing for use in applications, such as in the gear units of wind turbines, in which skidding (also known as sliding) may occur between the rollers and raceway (bearing) surfaces.

When the rotational speed of rollers in a roller bearing is insufficient to ensure pure rolling of the raceways, skidding may occur between the rollers and raceway surfaces. Rollers typically decelerate in their rotational speed when in the unloaded zone of the bearing and accelerate in rotational speed due to contact with the raceways when in the loaded zone. The force needed to accelerate the rollers is, among other factors, dependent on the speed difference between the roller and raceway surfaces, and also the roller inertia. Prolonged skidding is undesirable because it can cause surface damage, such as material smearing, and lead to bearing failure. In particular, metal to metal contact can occur when the aforementioned operating conditions lead to an insufficient oil layer thickness, that resulting in a generation of heat which can cause skid smearing and subsequent bearing failure.

When bearings run under low or zero load conditions, the loaded zone becomes very small or does not exist. In consequence relative sliding between the roller and raceway surfaces is likely to occur. If a load is then suddenly applied to the bearing and the relative surface speeds of the rollers and raceways is high, smearing of material could occur as the rollers are accelerated. Over a period of time this can lead to significant surface damage.

In the multi-stage gear units of wind turbines the aforementioned conditions often can arise in respect of the bearings of the high speed and intermediate shafts. Turbulence in the wind can cause drastic load changes on the gear unit and cause rollers to decelerate during low-load and accelerate again when the load increases. During controlled deceleration of the wind turbine

rotor blades, e.g. to a stationary condition, the torque direction on the shafts of the gear unit can often reverse, leading to a shift in the loaded zone position and roller skidding.

The present invention seeks to provide a roller bearing in which the aforedescribed problems which can lead to bearing failure are mitigated or overcome.

In accordance with one aspect of the present invention there is provided a roller bearing comprising a plurality of bearing rollers located between confronting bearing surfaces, said bearing surfaces being rotatable one relative to the other about the rotational axis of the bearing, and said bearing comprising biasing means which provides a force acting in a direction between said confronting bearing surfaces whereby, under all load conditions for which the bearing is designed for use, each bearing roller is retained in contact with each of said confronting bearing surfaces.

The invention is particularly applicable to a roller bearing of the type which, in use, is loaded primarily in a radial direction, the bearing thus comprising bearing rollers located radially between inner and outer bearing surfaces as considered relative to the rotational axis of the bearing and having said biasing means providing a force which acts in a radial direction relative to said axis of rotation. Alternatively, however, the roller bearing of the invention may be of a type which, in use, is loaded primarily in an axial direction, the bearing thus comprising bearing rollers located axially between confronting, axially spaced, bearing surfaces as considered relative to the direction of the rotational axis of the bearing and having said biasing means providing a force which acts in said axial direction.

The bearing surfaces may be provided by a pair of bearing rings in conventional manner, for example inner and outer bearing rings in the case of a radial type roller bearing. Alternatively one or each of said bearing surfaces

may be defined by the surface of another component in an integrated type construction in which said other component performs an additional function.

The invention is of particular applicability to a roller bearing in which the bearing rollers are cylindrical, such as in a radial type bearing, but may be employed also for bearings comprising taper type bearing rollers, such as may be used in an axial type bearing, or other types of roller bearings such as spherical roller bearings and CARB toroidal roller bearings.

The biasing force may be provided by deformability of the or each bearing roller per se which thus will serve as said biasing means, or may be provided by an additional element, for example a deformable element secured relative to one of the confronting bearing surfaces. Additionally or alternatively it is envisaged that a bearing surface may serve as said biasing means to provide the biasing force, for example by virtue of a part of a bearing surface being of a non-cylindrical shape when in an unstressed condition, and deformable slightly towards a cylindrical shape (in the case of a cylindrical roller bearing) when acted upon by a bearing roller located between confronting surfaces.

A bearing roller may be adapted to act as said biasing means by providing that when in an unloaded condition the body of material which defines an end region of the roller, as considered in the direction of the axis of rotation of the roller, is provided with an undercut or similarly relieved formation, and that the outer surface of the roller has a dimension which is greater than that of said outer surface at a position axially inwards from said end region. The end region thus may be provided with a radially inwardly deformable overhang or lip-like region which, in the assembled bearing, is deformed inwards thereby to result in the bearing roller having, as considered in longitudinal cross-section, a substantially rectilinear bearing surface and also exerting the aforedescribed biasing force to maintain contact between the roller and each of the confronting bearing surfaces. Preferably each end region of the roller is of a similar shape.

In a manner substantially equivalent to the roller construction described in the preceding paragraph, one or each of the confronting bearing surfaces may have at least one end region which is deformable i.e. deformable in a radial direction in the case of a radial type bearing or deformable in an axial direction in the case of an axial type bearing. An undercut or other such end relief preferably is formed in that half of the thickness of a bearing ring which is adjacent the bearing surface of that bearing ring.

The present invention does not require that either of the bearing surfaces or the rollers necessarily shall comprise an integral region of a shape which is more readily deformable than the remainder of the body of the respective bearing ring or roller. The invention provides that in addition or alternatively each bearing roller and/or at least one of the bearing surfaces may have associated therewith a deformable component which serves as biasing means. Said deformable component may comprise a material which is compressible and/or may be compressible in consequence of flexibility and shape of the component. Preferably the component is elastically deformable, and more preferably is an elastomeric material.

The roller bearing of the invention may comprise a bearing cage or may be cageless, e.g. it may be of the full complement type.

The invention provides also a multi-stage gear unit in which at least one of a high speed and intermediate shaft is supported by a roller bearing of a type in accordance with the present invention.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings in which:-

Figure 1 is a cross-section of part of a roller bearing in accordance with a first embodiment of the present invention;

Figures 2 and 3 show respectively a part of the bearing of Figure 1 before and after the bearing has been assembled;

Figure 4 shows in cross-section part of a roller bearing in accordance with a second embodiment of the present invention;

Figure 5 shows a part of the bearing of Figure 4 before the bearing has been assembled;

Figures 6 to 8 show, in relation to a third embodiment of the present invention, views corresponding to those of Figures 1 to 3, and

Figure 9 shows in cross-section part of a roller bearing in accordance with a fourth embodiment of the present invention.

Figure 1 shows part of radial type roller bearing 10 comprising an outer bearing ring 11, an inner bearing ring 13 and one of a plurality of cylindrical roller bearings 12 positioned between the confronting bearing surfaces 16, 19 of the inner and outer rings.

The inner ring 13 (see Figure 2) is machined to provide at each end region 14 a circumferentially extending zone 15 which protrudes radially outwards above the normal working surface 16. In addition, the end region 14 is formed with an annular recess 17 in the radially outer half of the thickness of the ring 13 thereby to form a radially deformable lip region 18 which comprises said zone 15. Thus the radial stiffness of the inner ring is reduced at said end region. The extent to which the zone 15 protrudes above the bearing surface 16 and flexibility of the lip region 18, are selected having regard to factors which may

include the amount of radial clearance in the bearing, operating speed and roller inertia.

When the bearing is in an assembled condition (see Figure 3) the lip region 18 is deformed radially inwards due to contact with the bearing surfaces 9 of the rollers 12 which are thereby also urged radially outwards to bear against the outer ring 11.

Figure 4 shows an embodiment in which a protrusion and undercut are provided on each roller instead of one or each bearing ring as above described.

The roller 20 is machined to provide, at each end 21, 22, a zone 23 which protrudes radially outwardly from the intervening bearing surface 24 when the roller is in an unloaded condition. Additionally each end is formed with a recess 25 such that a pair of deformable annular lip regions 28 are formed. In the assembled condition as shown in Figure 4 the lip regions act as biasing means to maintain contact between the roller and each of the inner and outer bearing rings 26, 27.

In the embodiment of Figures 6 to 8 biasing means is provided in the form of a pair of compressible elastomeric rings 30, 31 position in the corner regions of the outer ring 32, between the cylindrical bearing surface 33 and respective axial abutment faces 34, 35. In this embodiment the biasing rings 30, 31 are of a hollow, tubular form thereby to provide compressibility primarily by virtue of the shape of each ring, but rings of a solid cross-section and of compressible material alternatively may be employed. Figure 7 shows a biasing ring 30 in an unstressed condition and Figure 8 shows that biasing ring in situ compressed between the outer bearing ring 32 and the corner of a roller 36.

In an alternative configuration, shown in Figure 9, a solid section biasing ring 40 of compressible material is provided in an annular groove 41 formed centrally in the bearing surface of the outer bearing ring 42.

In each of the embodiments of Figures 6 to 9 the biasing ring serves to ensure that the roller is maintained in contact with, and experiences the relative rotational movement between, the inner and outer bearing rings.

In the aforedescribed embodiments of the invention the load bearing capacity of the bearing is less than that of a standard, conventional bearing of otherwise similar construction because of the fact that the load carried by the low stiffness zones is insignificant. However, although such bearings may be more expensive as compared with a standard bearing, they will have the advantage of better resisting slip phenomena, which in many cases is the underlying cause of ultimate bearing failure.